JUPITER.

Jan.	1,	17	43	− 23	5	6 24 A.M.	11	1 A.M.	3	38 P.M.
Feb.	1,	18	12	− 23	9	4 51	9	28	2	5
Mar.	1,	18	34	− 22	59	3 23	8	0	12	37

SATURN.

Jan.	1,	18	34	− 22	37	7 13 A.M.	11	52 A.M.	4	31 P.M.
Feb.	1,	18	49	− 22	24	5 26	10	5	2	44
Mar.	1,	19	0	− 22	10	3 47	8	27	1	7

URANUS.

Jan.	1,	16	52	− 22	31	5 31 A.M.	10	10 A.M.	2	49 P.M.
Feb.	1,	16	59	− 22	42	3 37	8	15	12	53
Mar.	1,	17	2	− 22	47	1 51	6	29	11	7 A.M.

NEPTUNE.

Jan.	1,	5	49	+ 22	11	3 46 P.M.	11	6 P.M.	6	26 A.M.
Feb.	1,	5	46	+ 22	11	1 40	9	0	4	20
Mar.	1,	5	45	+ 22	11	11 49 A.M.	7	9	2	29

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Off left-hand limb as seen in an inverting telescope.)

II, D,	Jan. 13,	5^h 0^m A.M.	II, D,	Feb. 7,	1^h 59^m A.M.
I, R,	16,	2 52	I, D,	8,	3 1
III, D,	16,	6 23	II, D,	14,	4 33
I, D,	23,	4 46	I, D,	15,	4 55
I, D,	30,	6 39	III, D,	21,	2 12
			III, R,	21,	4 45
			I, D,	22,	6 49
			I, D,	24,	1 18
			I, D,	28,	6 10

"AN ATLAS OF REPRESENTATIVE STELLAR SPECTRA."*—A REVIEW.

By W. W. CAMPBELL.

This is the title of "PUBLICATIONS OF SIR WILLIAM HUGGINS'S OBSERVATORY, VOL. I.," by Sir WILLIAM HUGGINS, K. C. B., and Lady HUGGINS, issued in March, 1900. Outwardly, the volume is a masterpiece of the bookmaker's art. It is doubtful if any other astronomical book of this century is so

* Published by WM. WESLEY & SON, London. £1 5s net.

truly an *édition de luxe*. In addition to thirteen half-sheet pages of celestial spectrograms, there are splendid photographic illustrations of the observatory and its instruments; and the charm of the book is greatly enhanced by some fifteen headpieces and initials exquisitely sketched by the pen of Lady HUGGINS. The pleasure of the reader is increased by these evidences that the beautiful in astronomy has not escaped the esthetic sense of the authors.

These external charms have their counterparts in the text. It is a record of pioneer work in stellar spectroscopy, written in sufficient detail to interest the technical astrophysicist, but in language so simple that the general reader can comprehend equally well.

Sir WILLIAM HUGGINS'S observatory, founded in London in 1856, contained at first a five-inch Dolland telescope, which was replaced by an eight-inch Clark in 1858. His work was mainly in the line of physical observations of the planets. KIRCHHOFF'S discovery of the significance of the Fraunhofer spectrum-lines in 1859 attracted HUGGINS'S attention to the possibility of applying these newly discovered principles to the study of the stars. Inviting Dr. MILLER, Professor of Chemistry in King's College, to join him in the work, these gentlemen constructed a small spectroscope and attached it to the eight-inch refractor; and their great work of laying the foundations of the spectroscopic astronomy began at once. "The observatory became a meeting-place where terrestrial chemistry was brought into direct touch with celestial chemistry. The characteristic light-rays from terrestrial hydrogen shone side by side with the corresponding radiations from starry hydrogen, or else fell upon the dark lines due to the absorption of hydrogen in *Sirius* or in *Vega*. Iron from our mines was matched, light for dark, with stellar iron from opposite parts of the celestial sphere. Sodium, which upon the Earth is always present with us, was found to be widely diffused through the celestial spaces.

"The time was, indeed, one of strained expectation and of scientific exaltation for the astronomer, almost without parallel; for nearly every observation revealed a new fact, and almost every night's work was red-lettered by some discovery."

The preliminary results obtained by HUGGINS and MILLER, showing that the chemistry of the solar system prevails wherever the spectroscope was pointed, were communicated to the Royal

Society in 1862. It is a remarkable fact that on the day their paper was read the Society learned that similar observations had been made by RUTHERFURD in New York. A little later, the spectra of the stars were also studied by SECCHI in Italy, and by VOGEL in Germany.

Perhaps the most interesting observation of all was that made by HUGGINS in August, 1864, on the planetary nebula in *Draco*. It is hardly possible for the younger members of our profession to realize the profound interest taken in the discussion of questions concerning the nebulæ. The increasing power and perfection of telescopes had enabled HERSCHEL and others to resolve one nebula after another into stars; and it was held by many that all nebulæ were probably clusters of stars, which the powerful telescopes of the future would resolve. HERSCHEL himself was of the opinion that the very extended nebulosities, at least, were composed of matter self-luminous, "more fit to produce a star by its condensation, than to depend on the star for its existence."

HUGGINS'S observation of the *Draco* nebula solved the problem. The spectrum was monochromatic. First, one bright line was visible; and later two others were detected. This nebula was "not an aggregation of stars, but a luminous gas." Of sixty nebulæ and clusters examined, about one third gave the bright-line spectrum, indicating their gaseous nature.

The first observations of the spectrum of a "new star" were made by HUGGINS and MILLER in May, 1866.

About this time HUGGINS recognized the possibility of measuring the motion of a star in the line of sight, by means of the displacement of its spectrum; and a spectroscope for this purpose was constructed. While the enormous difficulties of the subject were not overcome, yet his ideas were opening up a field whose limits cannot even now be discerned.

HUGGINS'S observations of a comet spectrum in 1868 led at once to the recognition of the important part played in comets by carbon; and his photograph of a comet spectrum in 1881 led to the detection of nitrogen radiations in these bodies.

His resources were greatly increased in 1870 by the loan, from the Royal Society, of a 15-inch Grubb refractor and an 18-inch speculum reflector.

It is interesting to note HUGGINS'S courage in trying new methods: stellar spectrograms were attempted in 1863 with wet-plates; but these plates were impracticable, and their use had to

be given up. His photographic work began again in 1875–76, when rapid dry-plates were available. Many of the spectra on which he had worked visually were now studied photographically. His photographs have been taken largely with spectrographs provided with Iceland-spar prisms and quartz lenses. These materials transmit the radiations of short wave-lengths, and his spectra of the brighter stars extend far into the ultra-violet.

Sir WILLIAM HUGGINS'S chief interest has been in reference to the evolution of the stars; and his photographs are discussed almost entirely from this point of view. His earlier observations on the visual portions of the spectra led him to arrange the brighter stars as to their age, or state of development, about as follows:—

Sirius.— *Vega.*
. . . . . .
α *Aquilæ.*
Rigel.
α *Cygni.*
. . . . . .
. . . . .
Capella.—The Sun.
Arcturus.
Aldebaran.
Betelgeux.

His researches on the ultra-violet spectra of those stars confirm, in his opinion, the above order of arrangement. The discussion of this question is the chief technical interest of the volume. It is based on HELMHOLTZ'S law that the mutual gravitation of the previously widely separated portions of a star is sufficient to account for the high temperature generated in it; on LANE'S law that the temperature of a star will increase so long as the star is purely gaseous, after which the temperature will decrease; and on the generally accepted fact that as the temperature rises the maximum of the continuous spectrum shifts to the violet. HUGGINS'S observations have led him to the somewhat unexpected conclusion that the true continuous spectrum is relatively stronger in the ultra violet of the metallic or solar type stars, such as *Procyon* or *Capella*, than in the white stars, *Sirius* or *Vega*. HUGGINS'S photographs taken with spar and quartz optical trains are practically the only ones extant which bear strongly upon this important discovery. Confirmatory photo-

graphs, covering a large number of stars, are greatly to be desired. Granting HUGGINS'S result to be indeed a fact, his stellar classification follows with comparative ease and certainty.

The authors describe, further, a series of experiments on the behavior of the calcium spectrum under varying conditions, and the results furnish further confirmation of their system of classification.

The book is referred to on the title page as Volume I. The appearance of subsequent volumes will be anticipated with interest.